EROL KALKAN, Ph. D., P. E.

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(1) BIOGRAPHY

Dr. Erol Kalkan is a research structural engineer and manager of the National Strong Motion Network with the United States Geological Survey.

He earned his B.Sc. degree in Civil Engineering and M.Sc. degree in Engineering Seismology from the Middle East Technical University. His second M.Sc. degree in Structural Engineering is from the Bosporus (Bogazici) University in Turkey. His doctorate degree in Structural Engineering (major) and in Geotechnical Engineering (minor) is from the University of California, Davis.

Dr. Kalkan has years of experience in conducting multi-component research and consulting as a practitioner. He is the author and co-author of 78 peer-reviewed publications including 39 journal papers on various issues in structural engineering and engineering seismology. He is an active member of Pacific Earthquake Engineering Research Center - Ground Motion Selection and Modification Research Committee, American Society of Civil Engineers (ASCE) - Seismic Effects Committee, and Earthquake Engineering Research Institute (EERI) – Heritage and Existing Structures Committee.

Dr. Kalkan is the recipient of the “2008 American Society of Civil Engineers Raymond C. Reese Research Prize in Structural Engineering”. He has been also granted “2008 EERI-FEMA NEHRP Professional Fellowship in Earthquake Hazard Reduction”.

He has served as a guest editor of three special journal issues in the international journal of *Engineering Structures*, *ASCE Journal of Structural Engineering* and *Seismological Research Letters*. He is currently acting as an associate editor for *ASCE Journal of Structural Engineering* and *Seismological Research Letters.*

(2) EDUCATION

School	Dates	Major	Degree	Year
Middle East Technical University	1993-1998	Civil Engineering	B.Sc.	1998
Bosporus University	1999-2001	Structural Engineering	M.Sc.	2001
Middle East Technical University	2000-2001	Engineering Seismology	M.Sc.	2001
University of California, Davis	2003-2006	Structural Eng. (major), Geotech. Eng. (minor)	Ph.D.	2006

(3) TECHNICAL TRAINING RECEIVED

Business Process Re-Engineering (1999, Istanbul, Turkey)
Supervisory Management (2009, USGS, Menlo Park)
Coulomb Stress Computation (2010, SCEC, Palm Springs)

(4) PROFESSIONAL EXPERIENCE

a. PRESENT PROJECTS

My current and past projects can be defined in two main groups, first group is related to the USGS National Strong Motion Network; second group is related to the earthquake engineering research.

1. DATES From: Oct. 2008 To: Present

   Description: **Manager - National Strong Motion Network**

   I am currently responsible for national strong motion network operations, and supervising seven electronics technicians (four in Menlo Park and three in Pasadena). My primary duty is to plan and organize workflow for instrumentation of structures and new free-field sites as well as maintenance and upgrades of existing strong motion network. I am also responsible for designing instrumentation plan for new structural installation projects, preparation of purchase orders and contracts with external agencies and private companies. I also promote and represent national strong motion program in national and international venues and meetings. In addition, I search for external funding, manage existing reimbursable contracts, initiate and prepare new collaborative technical agreements between private and government agencies. Currently, I am managing the following reimbursable contracts and funds:

   - Oregon Department of Transportation (approx. $25k/yr)
   - Metropolitan Water District, Los Angeles (approx. $50k/yr)
   - U.S. Veteran Affairs (approx. $100k/yr)
   - University of Puerto Rico (UPR) ($10k/yr)
   - Seattle City Light (SCL) ($10k/yr)
   - City of Anaheim (approx. $20k/yr)
   - Utah State Capitol ($5k/yr)
   - Army Corp of Engineers (approx. $100k/yr, with help of Roger Borcherdt)
   - ANSS Upgrades (approx. $300k/yr)
   - Network Operations (approx. $500k/yr)

   Funding: ANSS + all reimbursable accounts

   Budget: Approx. $1 million each year

   Project PI: Erol Kalkan

2. DATES From: Feb. 2009 To: Present

   Description: **Instrumentation of Veteran Affairs (VA) Hospitals in High and Very High Seismic Regions and Developing Earthquake Damage Detection, Alerting and an Early Warning System**

   Project objectives are to instrument 27 VA medical centers in high and very high seismic regions for real-time structural health monitoring, and to develop an automated damage detection, alerting

and local early warning system. I am currently managing this entire project; my responsibilities include site-surveys, preparation of instrumentation designs, communication with hospital managements, preparation of purchase orders and contracts, periodically inform VA for progress, and renew the VA-USGS contract each year. In addition, I am managing the earthquake damage detection software development for real-time structural health monitoring of instrumented structures.

Funding: U.S. Veteran Affairs

Budget: $7 million (for 3.5 years)

Project PI: Erol Kalkan

3. DATES From: Sept. 2009 To: Present

   Description: **Experimental Evaluation of Ground Motion Scaling Methods for Nonlinear Analysis of Structural Systems**

   Project's broad objective is to experimentally verify ground motion selection and scaling methods considering a wide range of structural properties, seismic hazard conditions, and hazard levels in order to improve design practice for nonlinear analysis of building structures. My responsibility is to provide technical assistance on ground motion scaling methods, select and prepare an appropriate ground motion sets for shake table experiments, and evaluate the test results. I am currently co-advising a M.Sc. student as part of this project.

   Funding: National Science Foundation

   Budget: $165k (for 2.5 yrs)

   Project PI: Prof. Yahya Kurama (University of Notre Dame), I am the co-PI on this project.

4. DATES From: Nov. 2008 To: Present

   Description: **Development of Ground Motion Selection and Scaling Procedure and Assessment and Refinements of Conditional Mean Spectrum**

   Project's broad objective is to develop practical guidelines for ground motion selection and scaling for nonlinear finite element analysis of structures. One of the components of this project is to define more realistic target (design) spectrum using the concept of conditional mean spectrum. I am fully responsible for all computations and developments. I am also co-advising a UC Berkeley Ph.D. student in this project.

   Funding: USGS

   Budget: -

   Project PI: Erol Kalkan (collaborator, Prof. Anil K. Chopra at UC Berkeley)

5. DATES From: Apr. 2010 To: Present

   Description: **Long Period Ground Motion Amplification in and around the Los Angeles Basins**

   Project's broad objective is to characterize the long period ground motion amplification in and around the Los Angeles basins in order to develop a basin amplification map to be used in seismic hazard computations and ultimately in the seismic-resistant design of long period structures such as oil tanks, tall-buildings, base-isolated

structures and bridges.

Funding: USGS

Budget: -

Project PI: Erol Kalkan (collaborator, Dr. Ken Hatayama – visiting scientist from Japan)

b. PREVIOUS PROFESSIONAL POSITIONS

1. DATES From: Oct. 2007 To: Oct. 2008

   Position**:** **Senior Seismologist**, Seismic Hazard Mapping Program, California Geological Survey, Sacramento, CA

   Description: I was responsible for deterministic and probabilistic seismic hazard computations and hazard mapping projects for California, and reviewing strong motion selection and scaling sections of geotechnical reports for new hospital and school projects in California.

2. DATES From: Oct. 2005 To: Oct. 2007

   Position: **Assoc. Seismologist,** California Strong Motion Instrumentation Program, California Geological Survey, Sacramento, CA

   Description: I was responsible for ground motion processing for earthquakes in California, and structural instrumentation projects within the state.

3. DATES From: Oct. 2006 To: Oct. 2008

   Position: **Private Consultant** for International Engineering and Engineering-Seismology Projects

   Description: I worked as a private consultant for international seismic hazard assessment and mapping projects for hydroelectric and nuclear power plants and tunnels.

4. DATES From: July 2003 To: Oct. 2005

   Position: **Research and Teaching Assistant,** Department of Civil and Environmental Engineering, University of California, Davis.

5. DATES From: June 2002 To: May 2003

   Position: **Research Assistant,** Department of Civil and Environmental Engineering, Rensselaer Polytechnic Institute, Troy, NY.

(12) SIGNIFICANT RESEARCH or DEVELOPMENT ACCOMPLISHMENTS

a. RECENT ACCOMPLISHMENTS

My overall vision in research is to close the gab between the structural engineering practice and engineering seismology. During my 10 year career, my research studies have been in the field of earthquake engineering amalgamating concepts of engineering seismology with structural engineering in order to better understand response of various structural systems to earthquake excitations, and predict the seismic demands. My recent accomplishments inline with this objective within the last 5 years can be best viewed through my publication list (or my professional page: https://profile.usgs.gov/ekalkan). I have provided below only the three of my recent accomplishments.

1. **Development of Practical Guidelines to Select and Scale Earthquake Records for Nonlinear Response History Analysis of Structures (Publications #A60, A65, A68, B1, B3)**

BACKGROUND – Over the past decade, considerable progress have been made in developing tools to predict nonlinear response of structures to ground motions, an important consideration in the design and assessment of earthquake-resistant structures. With increase in computational power, non-linear response history analysis (RHA) is becoming a common tool in practice. This rigorous method of analysis requires a suite of records as direct input. These records should be selected and scaled appropriately to make them compatible with the site-specific hazard level considered. Today, practitioners are faced with emergence of numerous different intensity-based and spectral-matching type methods for scaling of records without having sound documentation for their details or their suitability under different hazard conditions or structural systems. Considering the large variations in sources influencing the ground motions' intensity and frequency content (e.g., magnitude, distance, directivity, geological and topographical conditions etc.), selection of records with confidence has also remained a major challenge for engineers. Owing these facts, there is an urgent need for practical guidelines that can bridge the gap between seismologists and structural engineers so that both sets of knowledge and understanding can join to describe how a certain suite of records would affect the response results, and how they should be selected and scaled to achieve robust prediction of earthquake response of structures.

RESULTS AND SIGNIFICANCE – This Earthquake Engineering Research Institute/FEMA/ NEHRP funded project provides design guidelines for engineers and engineering-seismologists to select and scale ground motions for use in nonlinear response history analysis of buildings and bridges. In the developed modal-pushover based ground motion scaling (MPS) methodology, the ground motions are scaled to match (to a specified tolerance) a target value of the inelastic deformation of the first-"mode" inelastic single-degree-of-freedom (SDF) system whose properties are determined by first-"mode" pushover analysis. Appropriate for first-"mode" dominated structures (e.g., low and mid-rise buildings), this approach is extended for structures with significant contributions of higher modes (e.g., tall buildings) by considering elastic deformation of second-"mode" SDF system in selecting a subset of the scaled ground motions. Based on results presented for four bridges, and six buildings, the accuracy and efficiency of the developed MPS procedure are established and its superiority over the regulatory ASCE/SEI 7-05 scaling procedure is demonstrated.

IMPACT – This study has been influencing the design practice since 2010 following the publication of two USGS Open File Reports summarizing the MPS for building structures and bridges. Our proposed methodology has been used in design practice (including the Nuclear Industry) by structural engineering firms in their design projects, where ground motion time series are required for design verification. The dedicated web pages of this study (http://nsmp.wr.usgs.gov/ekalkan/MPS/index.html & http://nsmp.wr.usgs.gov/ekalkan/MPS_Bridge/index.html) have been visited more than 500 times in the last six months after its release by visitors from more than 30 countries. An associated NEHRP proposal is currently underway in order to include the developed methodology in the next generation of the U.S. International Building Code. Considering the importance of the subject, I have also compiled a special volume of journal issue in the Journal of Structural Engineering with Nico Luco as the guest-co-editor.

2. Seismic Hazard Mapping of California Considering Site Effects (Publications #A55, A64)

BACKGROUND – The U.S. Geological Survey has released a 2008 version of the National Seismic Hazard Maps. These maps plot the peak ground acceleration (PGA) and spectral acceleration (SA) at 0.2 and 1.0 sec with 2% and 10% probability of exceedance (PE) in 50 years. These acceleration levels were computed for uniform "firm rock" site conditions only (VS30 = 760 m/sec), and therefore the potential spatial variability of ground motion associated with different site conditions is not considered.

RESULTS AND SIGNIFICANCE – In this study, we have combined the National Seismic Hazard model with the California geologic map showing 17 generalized geologic units that can be defined by their VS30. We regrouped these units into 7 VS30 values and calculated a probabilistic seismic hazard map for the entire state for each VS30 value. By merging seismic hazard maps based on the 7 different VS30 values, a suite of seismic hazard maps was computed for 0.2 and 1.0 sec spectral ordinates at 2% PE in 50 years. The improved hazards maps explicitly incorporate the site effects and their spatial variability on ground motion estimates.

IMPACT – The SA at 1.0 sec map of seismic shaking potential for California has been now published as California Geological Survey Map Sheet 48; this map allows non-scientists to understand the overall distribution of seismic shaking hazards, including the effects of amplification by near-surface soils. The map has been distributed to planners and emergency preparedness officials by CGS to evaluate the relative hazards across the state so that hazard mitigation efforts can be focused on the most hazardous areas. A dedicated web page (http://nsmp.wr.usgs.gov/ekalkan/California/index.html) of this project provides an interactive environment for the visitors to explore the seismic hazard and geology of California using the Google-Earth API; visitors from more than 20 countries have visited this web page 381 times since May 2010 after its release. The manuscript summarizing this study became the cover story of the journal of Earthquake Spectra (Nov. 2010 issue). The next generation of national hazard maps is expected to incorporate the site effects following our study.

3. Ground Motion Prediction Modeling (Publications #A40, A53, A56, A61, A66)

BACKGROUND – Ground motion prediction equations (GMPEs) are the key players for probabilistic and deterministic seismic hazard assessment, and for emergency response products of USGS such as ShakeMAP, LOSS-PAGER.

RESULTS AND SIGNIFICANCE – In this study, two new ground motion attenuation models (for peak-ground acceleration (PGA) and spectral acceleration (SA)) were developed using the NGA database. A novel feature of the predictive model for PGA is its new functional form structured on the transfer function of a single-degree-of-freedom oscillator. Our SA model is developed based on the PGA model. Unlike other district SA models available in the literature, our SA model is generated as a continuous function of few independent parameters (magnitude, distance and soil-class), thus it eliminates the classical exhausted matrix of estimator coefficients used in the current models and provides significant ease in its implementation in predicting response spectral shape.

IMPACT – Our GMPEs have been widely used for ground motion prediction in seismic hazard projects in practice (including the Nuclear Industry) and in research within U.S. and abroad.

b. **OTHER CAREER ACCOMPLISHMENTS**

1. Investigating Effects of Fling-Step and Forward Directivity on the Seismic Response of Buildings (Publication # A36)

BACKGROUND – Near-fault ground motions are often characterized by coherent long-period velocity pulses that may result in sudden and extreme deformation demands in structural components as experienced during the 1994 Northridge, 1999 Kocaeli and Duzce, and 1999 Chi-Chi earthquakes.

RESULTS AND SIGNIFICANCE – This study investigates the consequences of well-known characteristics of pulse-type motions on the seismic response of moment-frame steel buildings. The severity of inelastic demands was evaluated for four, six and thirteen-story existing steel buildings subjected to near-fault ground motions with fling-step and forward directivity, and compared to their response to far-fault ground motions. Additionally, idealized pulses are utilized in a separate evaluation study to gain further insight into the effects of high amplitude pulses on structural demands. Simple input pulses were also synthesized to simulate artificial fling-step effects on ground motions originally having forward directivity. This study showed that median maximum demands as well as the dispersion in the peak values for the three buildings were higher for near-fault records than far-fault motions. The arrival of the velocity pulse in a near-fault record causes the structure to dissipate considerable input energy in relatively few plastic cycles whereas cumulative effects from increased cyclic demands are more pronounced in far-fault ground motions. For pulse-type input, the maximum demand is a function of the ratio of the pulse period to the fundamental period of the structure. More significantly, records with fling effects were found to excite systems primarily in their fundamental mode while waveforms with forward directivity in the absence of fling caused higher modes to be activated. It is also concluded that the acceleration and velocity spectra, when examined collectively, can be utilized to reasonably assess the damage potential of near-fault records.

IMPACT – The results of this study clearly showed the impacts of the near-fault ground motions on the response of structures to the engineering community. The paper summarizing the results of this study has been cited 31 times since 2006. Following the publication of this study, numerous graduate students and researchers have requested its ground motion set. These sets, containing fling records that I processed to retain the residual displacements, have been used in numerous graduate theses elaborating ground motion records having near-fault directivity.

2. Engineering Implementation of Six Degree-of-Freedom Ground Motion (Publications # A41, A42, A43, A52)

BACKGROUND – Rotational and vertical components of ground motion are almost always ignored in design or in the seismic performance assessment of structures despite the fact that vertical motion can be twice as much as the horizontal motion and may exceed 2g level, and rotational excitation may reach few degrees in the proximity of fault rupture. Coupling of different components of ground excitation may significantly amplify the seismic demand by introducing additional lateral forces and enhanced P-Δ effects.

RESULTS AND SIGNIFICANCE – We have postulated a governing equation of motion to compute the response of a single-degree-of freedom oscillator under a multi-component excitation. The expanded equation includes secondary P-Δ components associated with the combined impacts of tilt and vertical excitations in addition to the inertial forcing terms due to the angular and translational accelerations, and plus the

horizontal excitation. The elastic and inelastic spectral ordinates traditionally generated considering the uniaxial input motion are compared at the end with the multi-component response spectra of coupled horizontal, vertical and tilting motions.

IMPACT – This study for the first time propose the multi-component response spectrum, which reflects kinematic characteristics of the ground motion that are not identifiable by the conventional spectrum itself, at least for the near-fault region where high intensity vertical shaking and rotational excitation are likely to occur. Following our studies in this area, I have been invited to participate in the International Working Group of Rotational Seismology and their workshops held in Menlo Park in 2006 and Praque in 2010.

3. **Probabilistic Seismic Hazard Assessment for the Marmara Sea Region (Turkey) (Publications # A48, A58, A62)**

BACKGROUND – In 1999, two destructive earthquakes (Kocaeli and Düzce) occurred in the eastern part of the Marmara region on the North Anatolian fault (NAF) system. This strike-slip fault system cuts across northern Turkey for more than 1200 km and accommodates ~25 mm/yr right-lateral slip between the Anatolian and Eurasian plates. Since 1939, the NAF system has produced nine large earthquakes in a consistently westward-propagating sequence. Based on a renewal model, the probability of occurrence of M7.0 and greater earthquakes in the Marmara region that could directly influence the Istanbul metropolitan area was computed as 44 +/- 18% in the next 30 yr. As implied by the level of seismic risk, critical assessment of the regional seismic hazard is of paramount importance to facilitate and support a wide range of earthquake engineering applications.

RESULTS AND SIGNIFICANCE – Based on a probabilistic approach, seismic risk in the Marmara (Turkey) region are quantified on a set of hazard maps that provide peak horizontal ground acceleration (PGA) and spectral acceleration at 0.2 sec, and 1.0 sec on rock site condition. These acceleration levels were computed for maximum credible earthquake for 2% and 10% probabilities of being exceeded in 50 years corresponding to return periods of about 2475 and 475 years, respectively. The maximum PGA computed (at rock site) is 1.5 g along the fault segments of the NAF zone extending into the Sea of Marmara. The new maps generally show 10% to 15% increase for PGA, 0.2 sec, and 1.0 sec spectral acceleration across much of Marmara compared to previous regional hazard maps. Hazard curves and smooth design spectra for three site conditions—rock, soil, and soft-soil—are provided for the Istanbul Metropolitan area as possible tools in future risk estimates.

IMPACT – This most recent study, based on the general methodology developed for the U.S. national seismic hazard maps, helps to shed light on future assessments of risk to structures in the Marmara region and, serves as a reminder to improve design and construction practices to minimize losses of life and property. More than 200 visitors have visited the project's web pages including its Turkish version (http://nsmp.wr.usgs.gov/ekalkan/marmara/index.html) since June 2010 after its first release. RMS (Risk Management Solution) has been using our hazard analysis results including my ground motion prediction model for Turkey in their most recent loss and risk assessment model for Turkey and Balkans. Numerous consulting companies as well as insurance companies in Istanbul and its surroundings has used the hazard results presented in this study.

4. **Development of Adaptive Modal Combination Procedure for Nonlinear Static Analysis of Building Structures (Publications # A34, A35, A36)**

BACKGROUND – The advancement of performance-based procedures in seismic design relies greatly on advancements in analytical methods to predict inelastic dynamic response of building structures. A commonly utilized analytical method in practice for response prediction is nonlinear static analysis (that is, pushover analysis).

RESULTS AND SIGNIFICANCE – A new pushover technique utilizing adaptive multimodal displacement patterns is developed with the objective of retaining the advantages of both adaptive and modal pushover procedures. The proposed adaptive modal combination procedure eliminates the need to pre-estimate the target displacement and utilizes an energy-based scheme to achieve stable estimates of the seismic demand in conjunction with constant-ductility inelastic spectra. It is shown to provide reasonable estimates of seismic demand in typical moment frame structures for both far-fault and near-fault records.

IMPACT – This manuscript describing this study has been selected for the 2008 American Society of Civil Engineers Raymond C. Reese Research Prize. The prize was awarded for describing a notable achievement in research related to structural engineering and recommending how the results of that research can be applied to design. This paper has been cited by 45 times so far (according to the Google-Scholar), numerous researchers worldwide have requested for the adaptive pushover code that I developed in open source finite element analysis platform to use in their research studies.

(13) SCIENTIFIC LEADERSHIP

Since joining the USGS in Nov. 2008, I have played an active and ever growing role in promoting national strong motion project (NSMP) and use of its products in earthquake engineering within and outside of the USGS, and also conducting core research on structural engineering and engineering seismology. As a national strong motion network manager, my efforts include initiating new structural installation projects to better understand the behavior of structures under seismic actions, interacting with a broad range of outside institutions; and taking a leadership/management role in directions of USGS programs as a task leader. I have developed cooperative technical agreements with the University of Puerto Rico, Seattle City Lights, U.S. Veteran Administration, that brings external funding for instrumentation of new and maintenance of existing strong motion stations. I have organized numerous meetings in Menlo Park with instrument manufacturers (including Guralp, Kinemetrics Hewlett Packard, Reftek and Geosig) for demonstration of their new products to NSMP and Northern California Seismic Network staff. I organized a meeting in Menlo Park with Japanese strong motion network (KikNET and KNET) to share knowledge, experience and new projects of two institutes on strong motion network and operations. I have been hosting visiting scientists from Japan, Greek, Turkey and Colombia and conducting collaborative research with them. I am also serving as a co-advisor for two students (N.S. Kwong: Ph.D. student at UC Berkeley and A. O'Donnell: M.Sc. at Univ. of Notre Dame). In addition, I am presenting NSMP in national and international venues (including ANSS, NIC, State Seismic Safety Commission meetings), and promoting instrumentation and strong motion data usage from instrumented structures in engineering research community. I have initiated several new instrumentation projects currently under evaluation by other agencies; these are the University of Southern California (instrumentation of Information Technology Building in Downtown LA Campus), and Alaska DOT (instrumentation of Kodiak Island Bridge), instrumentation of two high-rise buildings (One Rincon Tower in San Francisco and LA Live Building in Los Angeles).

(14) SCIENTIFIC AND PUBLIC SERVICE

a. CURRENT MEMBERSHIPS IN PROFESSIONAL SOCIETIES

- Earthquake Engineering Research Institute, 2003 – Present
- Seismological Society of America, 2004 – Present
- American Geophysical Union, 2006 – Present
- American Society of Civil Engineers, 2006 – Present

b. TECHNICAL PRESENTATIONS (in chronological order)

2003

- Kalkan E. and Balkaya C., "Three-Dimensional Nonlinear Seismic Performance of Tunnel Form Buildings", *13th Annual Meeting of Earthquake Engineering Research Institute*, Portland, OR, 2003. (POSTER)
- Kalkan E., "Enhanced Seismic Resistant of Shear-Wall Dominant Building Structures", *State Engineering Week, New York Department of Transportation*, Albany, NY, 2003. (POSTER)

2004

- Kalkan E. and Kunnath S.K., "Method of Modal Combinations for Pushover Analysis of Buildings", *Thirteenth World Conference on Earthquake Engineering*, Vancouver, BC, 2004. (INVITED)

2005

- Kalkan E. and Gulerce U., "Artificial-Neural-Network based Ground Motion Attenuation Models", *Seismological Society of America Annual Meeting*, 27-29 April, Lake Tahoe, Nevada, 2005. (POSTER)
- Kunnath S.K., Jeremic B., Kalkan E., Larson L., Bauer, K. and Felten A. "Application of the PEER Performance-based Methodology for Seismic Assessment of the I-880 Viaduct", *California Department of Transportation Bridge Research Conf.*, Sacramento, 2005. (POSTER)
- Kunnath S.K. and Kalkan E., "Capacity Curves: The IDA Capacity Curves: The Need for Alternative Intensity Need for Alternative Intensity Factors", *Structures Congress*, April, 20-24, New York, 2005. (INVITED)

2006

- Kalkan E. and Kunnath S.K., "Evaluation of Two Ground Motion Scaling Methods to Estimate Mean Structural Demands", *Eighth National Earthquake Engineering Conference*, April 18-22, San Francisco, 2006. (INVITED)
- Kalkan E. and Kunnath S.K., "Evaluation of Adaptive Modal Combination Procedure for Vertically Irregular Structures", *Eighth National Earthquake Engineering Conference*, April 18-22, San Francisco, 2006. (POSTER)
- Kalkan E. and Erduran E., "Duration Effect on Seismic Response of Structures", *Eighth National Earthquake Engineering Conference*, April 18-22, San Francisco, 2006. (POSTER)
- Kalkan E., Haddadi H. and Shakal T., "Seismic Input Energy (EI) of Ground Motions During the 2004 (M6.0) Parkfield California Earthquake", *Eighth National Earthquake Engineering Conference*, April 18 - 22, San Francisco, 2006. (POSTER)

- Gulkan P. and Kalkan E., "Ground Motion Predictions for Turkish Earthquakes", *International workshop on comparative studies of the North Anatolian Fault and the San Andreas Fault (Southern California),* Istanbul, Turkey, 2006. (POSTER)
- Kalkan E., "Energy-based Ground Motion Scaling Procedure for Nonlinear Transient Analysis of Buildings", *Cosmos Annual Meeting*, November, Berkeley, 2006. (POSTER)
- Kalkan E., "Strong-Motion Geotechnical Downhole Arrays in California", *Pacific Earthquake Engineering Research Center Workshop on Evaluation of Nonlinear Site Response*, September 22, Oakland, 2006. (INVITED)
- Kalkan E., "Instrumented Moment Frame Steel Buildings Models", *Ground Motion Selection and Scaling Workshop*, *Pacific Earthquake Engineering Research Center* UC Berkeley, October 27, Berkeley, 2006. (INVITED)

2007

- Kalkan E. "Energy-based Ground Motion Scaling Procedure", University of California Berkeley, *Pacific Earthquake Engineering Research Center Annual Meeting*, January 19-20, San Francisco, 2007. (POSTER)
- Kalkan E., "Rotational Components and Their Impacts on Structural Systems", *First International Workshop on Rotation Seismology and Engineering Applications*, Sept., 2007, USGS, Menlo Park. (POSTER)

2008

- Kalkan E., Wills C.J. and Branum D. "Seismic Hazard Mapping of California Incorporating Spatial Variability of Site Conditions", *Third East Bay Earthquake Hazards Conference*, October, Hayward, 2008. (POSTER)
- Kalkan E. and Graizer V., "Impacts of Rotational Ground Motions on Structures", *American Geophysics Union Annual Meeting*, December, San Francisco, 2008. (POSTER)
- Graizer V. and Kalkan E., "Novel Approach to Strong Ground Motion Attenuation Modeling", *14th World Conference on Earthquake Engineering*, October 13, Beijing, China, 2008. (INVITED)

2009

- Kalkan E., Wills C.J. and Branum D. "Seismic Hazard Mapping of California Incorporating State Wide VS30 Map", *Seismological Society of America Annual Meeting*, April, Monterey, 2009. (POSTER)
- Graizer V., Kalkan E. and Lin, K.W., " Graizer-Kalkan Ground Motion Attenuation Model based on Atlas Database of Shallow Crustal Events", *Seismological Society of America Annual Meeting*, April, 2009, Monterey. (POSTER)
- Graizer V., Kalkan E. and Lin, K.W., "Global Ground Motion Prediction Model for Shallow Crustal Regions", *Southern California Earthquake Center Annual Meeting*, September, Palm Springs, 2009. (POSTER)
- Kalkan E. and Chopra A.K. "Development of Modal Pushover-based Ground Motion Scaling Procedure", *Earthquake Engineering Research Institute Annual Meeting,* February, Salt Lake City, 2009. (INVITED)
- Kalkan E. and Chopra A.K. "Modal Pushover-based Ground Motion Scaling Procedure for Nonlinear Analysis of Structures", *UJNR 41st Joint Panel Meeting*, Tsukuba, May, Japan, 2009. (INVITED)
- Kalkan E. and Chopra A.K. "Modal Pushover-based Ground Motion Scaling Procedure", *Structural Engineering Association of California Annual Convention*,

September, 2009, San Diego. (INVITED)

- Kalkan E. "Seismic Monitoring of Building, Bridges and Lifelines", *ERA/CUBE Partners Meeting*, Caltech, October, Pasadena, 2009. (INVITED)
- Kalkan E. "U.S. National Strong Motion Network: Recent and Ongoing Projects", *Second Euro-Mediterranean Meeting on Accelerometeric Data Exchange and Archiving*, November, Ankara, Turkey, 2009. (INVITED)

2010

- Graizer V., Kalkan E. and Lin, K.W., "Extending and Testing Graizer-Kalkan Ground Motion Attenuation Model Using Atlas Database of Shallow Crustal Events", *9th US National and 10th Canadian Conference on Earthquake Engineering*, July 28, Toronto, 2010. (INVITED)
- Kalkan E. and Graizer V., "Tilt Errors on Recorded Accelerations from Instrumented Structures", *Second International Workshop on Rotational Seismology*, October 12, Praque, 2010. (INVITED)
- Graizer V and Kalkan E., "Strong motion seismology and rotations: history and future directions", *Second International Workshop on Rotational Seismology*, October 12, Praque, 2010. (INVITED)
- Hatayama K. and Kalkan E., "Characteristics of Long-Period (3 to 10 s) Strong Ground Motions Observed in and around the Los Angeles Basin during the Mw7.2 El Mayor-Cucapah Earthquake of April 4, 2010", *Southern California Earthquake Center Annual Meeting*, Palm Springs, 2010. (POSTER)
- Hatayama K. and Kalkan E., 2010 AGU (INVITED)
- Kalkan E., Hatayama K., Segou M. and Sevilgen V., "Characteristics of Ground Motion Attenuation during the M7.2 El Mayor Cucapah (Baja) Earthquake", *Southern California Earthquake Center Annual Meeting*, Palm Springs, 2010. (POSTER)
- Kalkan E. and Chopra A.K., "Conditional Mean Spectrum: Assessment and Refinements", *Cosmos Annual Meeting*, Nov. Berkeley, 2010. (INVITED)

2011

- Segou M. and Kalkan E., "Ground Motion Attenuation during M7.1 Darfield and M6.3 Christchurch (New Zealand) Earthquakes and Performance of Global Predictive Models", *SCEC Annual Meeting*, Palm Springs, 2011. (POSTER)
- Hatayama K. and Kalkan E., "Long-Period (3 to 10 s) Ground Motions in and around the Los Angeles Basin during the Mw7.2 El-Mayor Cucapah Earthquake of April 4, 2010", *4th IASPEI / IAEE International Symposium*, August 23–26, 2011, University of California Santa Barbara. (POSTER)

c. RENDERING SCIENTIFIC JUDGMENT

Editorial Board

Associate Editor: *American Society of Civil Engineers Journal of Structural Engineering* (2010 – Present)

Associate Editor: *Seismological Research Letters* (2010 – Present)

Guest editor: International Journal of Engineering Structures special issue on *"Seismic Reliability, Analysis, and Protection of Historic Buildings and Heritage Sites*", (2008).

Guest editor: American Society of Civil Engineers, Journal of Structural Engineering special issue on *"Earthquake Ground Motion Selection and Modification Methodologies for Nonlinear Dynamic Analyses of Structures*" (March issue of 2011).

Guest editor: *Seismol*ogical Research Letters, special issue on "2011 Christchurch New Zealand Earthquake" (Nov/Dec issue of 2011)

Peer Review Participation

I generally review 10-15 journal articles a year.

ASCE Journal of Structural Engineering, 2004 – Present
American Concrete Institute (ACI) Journal, 2006 – Present
Engineering Structures, 2005 – Present
Journal of Earthquake Engineering 2007 – Present
Earthquake Engineering and Structural Dynamics, 2007 – Present
Soil Dynamics and Earthquake Engineering, 2007 – Present
Bulletin of Seismological Society of America, 2008 – Present
Geophysical Research Letters, 2009 – Present
Natural Hazards, 2009 – Present
Earthquake Spectra, 2006 – Present
Seismological Research Letters, 2006 – Present
Engineering Geology, 2008 – Present
Structural Engineering and Engineering Mechanics, 2010 – Present

Chair (Technical Subcommittee)

Earthquake Engineering Research Institute: *Heritage and Existing Structures Committee* (2008 – 2009)

Member (Technical Subcommittee)

University of California Berkeley, Pacific Earthquake Engineering Research Center: *Ground Motion Selection and Modification Research Committee* (2006 – Present)

Earthquake Engineering Research Institute: *Heritage and Existing Structures Committee* (2004 – Present)

American Society of Civil Engineers, Structural Engineering Institute: *Seismic Effects Committee* (2008 – Present)

U.S. - Japan Panel (UJNR) on Wind and Seismic Effects (2009 – Present)

LECTURESHIPS AND OTHER ACADEMIC SERVICE

Invited Seminars

"*Rotational Seismology*", University of California, Los Angeles - Department of Civil Engineering, May 2007.

"*Adaptive Nonlinear Analysis as Applied to Performance-Based Earthquake Engineering*", USGS Menlo Park, Feb. 2008.

"Adaptive Nonlinear Analysis as a New Tool for Practicing Engineers", Tufts University, May, 2008.

"*Nonlinear Static Analysis in Structural Engineering*", California State University, Sacramento, Department of Mathematics, Feb. 2008.

"*U.S. National Strong Motion Program Structural Instrumentation",* University of Southern California, Jan. 2010.

"*Future of the U.S. National Strong Motion Program",* University of California, Irvine, Department of Civil Engineering, May 2010.

"U.S. Geological Survey National Strong Motion Program", ARUP, San Francisco, Nov. 2010.

"*Assessment and Refinements on Conditional Mean Spectrum*", University of Notre Dame, Department of Civil Engineering, Dec. 2010.

"*U.S. National Strong Motion Project: Current Efforts and Future Directions for Alaska*", University of Alaska, Anchorage, Feb. 2011.

Courses

Matrix Structural Analysis using MatLAB, Fall 2005, University of California, Davis - Department of Civil and Environmental Engineering.

Theory of Structures, Spring 2008, California State University, Sacramento – Department of Civil and Environmental Engineering.

Graduate Students Advised

N.S. Kwong, Ph.D. student, Ground Motion Selection for Nonlinear Response History Analysis of Structures, University of California, Berkeley, (2010-Present).

A.P. O'Donnell, M.Sc. student, Experimental Evaluation of Ground Motion Scaling Methods for Nonlinear Analysis of Structural Systems, University of Notre Dame, Indiana. (2009-Present).

Visiting Scientists:

Present:

Dr. Margaret Segou (Seismologist)

Institute: University of Athens, Greece
Duration: Feb. 2011 – Feb. 2012
Funding: External Funds
Research Topic: Assessment of Ground Motion Prediction Equations and Development of Adaptive Probabilistic Seismic Hazard Analysis Method

Dr. Hasan Ulusoy (Structural Engineer)

Institute: University of California, Irvine
Duration: Sept. 2011 – Oct. 2012
Funding: External Funds
Research Topic: Development and Testing of Automated Damage Detection System for Instrumented Structures

Past:

Dr. Ken Hatayama (Seismologist)

Institute: National Research Institute of Fire and Disaster, Japan
Duration: April 2010 – April 2011
Funding: Japanese Government
Research Topic: Long Period Ground Motion Amplification in LA Basins during the M7.2 El-Major Cucapah Earthquake (USGS OFR is under preparation)

Dr. Juan Carlos Reyes (Structural Engineer)

Institute: Universidad los Andes, Colombia
Duration: Dec. 1, 2010 – Dec. 15, 2010; June, 1 2011 – July 31, 2011
Funding: Universidad los Andes, Colombia
Research Topic: Statistical Evaluation of ASCE/SEI 7 Ground Motion Scaling Method (USGS OFR available online and paper has been accepted for publication)

TECHNICAL TRAINING PROVIDED

I provided a technical training on the use of USGS national seismic hazard code to geologists and seismologists at the California Geological Survey in 2008.

SPECIAL ASSIGNMENTS

I served as a member of the proposal evaluation panel for California Geological Survey in 2006, and NEHRP proposal review panel in 2009. In 2009, I arranged the USGS open house booth for structural health monitoring, and provided interactive computer simulations for seismic performance of buildings during the 1994 Northridge earthquake.

OTHER TECHNICAL ACTIVITIES

Since 2008, I have been representing the national strong motion project in Advanced National Seismic Systems (ANSS) steering committee meetings, ANSS NetOps meetings, California Integrated Seismic Network meetings, and California and Alaska State Seismic Safety Commission meetings.

(15) TECHNOLOGY AND INFORMATION TRANSFER AND DISSEMINATION

Web Site Development – I have created and maintained a professional webpage (https://profile.usgs.gov/ekalkan) for distributing information related to my research studies and ongoing projects; its primary use is to disseminate information within the projects among internal and external collaborators in a timely fashion.

Visualizations of Seismic Hazard via Google-EARTH API - I have created innovative, dramatic visualizations of the interactive geology and seismic hazard maps embedded to the Google EARTH API. User can fly over and zoom in to maps on Google Earth working on the Internet browser. Example pages are:

- California Seismic Hazard: http://nsmp.wr.usgs.gov/ekalkan/California/CIM.htm
- California Surface Geology Map: http://nsmp.wr.usgs.gov/ekalkan/California/VS30.htm
- Seismic Hazard in Marmara, Turkey: http://nsmp.wr.usgs.gov/ekalkan/marmara/MIM.htm

(16) INVENTIONS, PATENTS HELD

An application for a patent for the structural damage detection and early warning system, which is currently under development, will be in order soon.

(17) HONORS, AWARDS, RECOGNITION, ELECTED MEMBERSHIPS

Outstanding Doctoral Research Award, University of California, Davis, 2004.

In recognition of potential impacts of my doctoral study on earthquake engineering practice.

American Society of Civil Engineers, Raymond C. Reese Research Prize in Structural Engineering, 2008.

In recognition of the paper from my Ph. D. research (Publication #A34) "Adaptive Modal Combination Procedure for Nonlinear Static Analysis of Building Structures" published in the *ASCE Journal of Structural Engineering*.

EERI-FEMA-NEHRP Professional Fellowship in Earthquake Hazard Reduction, 2008.

For my research to develop practical guidelines to select and scale earthquake records for nonlinear response history analysis of structures In collaboration with Prof. Anil K. Chopra at the Department of the Civil and Environmental Engineering, University of California, Berkeley.

Adjunct Professor, Department of Civil Engineering, California State University, Sacramento, 2008-2009.

USGS STAR Award, 2010

In recognition of my efforts to manage deployment of aftershock instruments in the aftermath of the 2010 M7.2 El-Mayor Cucapah earthquake.

USGS STAR Award, 2010

In recognition of my pivotal efforts with the National Strong Motion Network Operations and management of reimbursable contracts

(18) BIBLIOGRAPHY

Publication Summary (Total of 78 published, accepted and in-review reports since 2001)

	Journal Papers	Journal Discussions	Conference Proceedings	Reports and Chapters	Academic thesis, dissertation
A. Published and Accepted Reports	36	2	29	5	3
B. Submitted for Publication	3	-	-	-	N/A

a. PUBLISHED REPORTS (in chronological order)

To show the impact of journal paper publications, the number of times each paper has been cited, as found from Google Scholar, is noted in the last line of each entry; the most recent journal papers published in 2009, 2010 and 2011 are excluded.

2001

A1. Kalkan, E. Attenuation Relationship Based on Strong Motion Data Recorded in Turkey, M.Sc. Thesis, Middle East Technical University, Ankara, 2001.

A2. Kalkan, E. Seismic Evaluation of an Existing Multi Storey Reinforced Concrete

Building, M.Sc. Thesis, Bosporus University, Istanbul, 2001.

2002

A3. Gülkan, P. and Kalkan, E. "Attenuation Modeling of Recent Earthquakes in Turkey", *Journal of Seismology*: **6**(3), 397-409, 2002. **[61 citations]**

A4. Balkaya, C. and Kalkan, E. "Performance Based Seismic Evaluation of Shear-wall Dominant Building Structures", *Proc. of the Fifth International Congress on Advances in Civil Engineering*: Istanbul, Turkey, Sept. 25-27, 2002.

A5. Gülkan, P. and Kalkan, E. "Attenuation Characteristics of Turkey Based on Recent Strong Motion Data", *Proc. of the Fifth International Congress on Advances in Civil Engineering* (Keynote Paper), Istanbul, Turkey, Sept. 25-27, 2002.

A6. Balkaya, C. and Kalkan, E. "Behavior of Tunnel Form Building Structures Subjected to Earthquake Forces", *Proc. of the International Earthquake and Structural Engineering Symposium*: Middle East Technical University, Ankara, Turkey, Oct. 14, 2002.

2003

A7. Balkaya, C. and Kalkan, E. "Nonlinear Seismic Response Evaluation of Tunnel Form Building Structures", *Computers & Structures*, 81,153-165, Feb. 2003. **[16 citations]**

A8. Kalkan, E. "Computer-Aided Strengthening of Steel and Reinforced Concrete Telecommunication Poles", *Proc. of the Pacific Conference on Earthquake Engineering*: Christchurch, New Zealand, Feb. 13-15, 2003.

A9. Balkaya, C. and Kalkan, E. "Seismic Design Parameters of Shear-wall Dominant Building Structures", *Proc. of the 14th Mexican National Conference on Earthquake Engineering*, 2003.

A10. Gülkan, P. and Kalkan, E. "Parametric Estimation of Ground Motion Attenuation of Turkish Earthquakes", *Proc. of the International Conference on Advances and New Challenges in Earthquake Engineering Research (ICANCEER)*: August 15-20, 2002, Harbin and Hong Kong, China: Hong Kong Volume, Organizing Committee of the International Conference at the Hong Kong Polytechnic University, Hong Kong, pp. 33-49. 2003.

A11. Gülkan, P. and Kalkan, E. "Site-Dependent Spectra Derived from Ground Motion Records in Turkey", *Proc. of the Fib Symposium: Concrete Structures in Seismic Regions*: Athens, Greece, May 6-9, 2003.

A12. Balkaya, C. and Kalkan, E. "Estimation of Fundamental Periods of Shear-Wall Dominant Building Structures", *Earthquake Engineering and Structural Dynamics*: **32**, (7), 985-998, June 2003. **[18 citations]**

A13. Balkaya, C. and Kalkan, E. "Performance Based Seismic Evaluation of Shear-wall Dominant Building Structures", *Bulletin of the Istanbul Technical University*: **53**, (2), 65-72, Sept. 2003.

2004

A14. Kalkan, E. and Kunnath, S.K. "Lateral Load Distribution in Nonlinear Static Procedures for Seismic Design", *Proc. of the American Society of Civil Engineers, Structures Congress*: Nashville, TN, May 22-26, 2004.

A15. Kalkan, E. and Kunnath, S.K. "Method of Modal Combinations for Pushover Analysis of Buildings", *Proc. of the 13th World Conference on Earthquake Engineering*: Vancouver, BC, Canada, Aug.1-6, 2004. **[15 citations]**

A16. Balkaya, C. and Kalkan, E. “Relevance of R-factor and Fundamental Period for Seismic Design of Tunnel Form Building Structures”, *Proc. of the 13th World Conference on Earthquake Engineering*: Vancouver, BC, Canada, Aug.1-6, 2004.

A17. Balkaya, C. and Kalkan, E. “A Simple Formula to Predict Fundamental Period of Tunnel Form Buildings”, *Proc. of the 6th International Congress on Advances in Civil Engineering*: Istanbul, Turkey, Sept. 25-27, 2004.

A18. Balkaya, C. and Kalkan, E. “Effects of Coupled Shear Walls Openings on the Nonlinear Behavior of RC Building Structures”, *Proc. of the International Conference on Structural Engineering and Mechanics*, Cape Town, South Africa, 2004.

A19. Pamuk, A., Ling, H.I., Leshchinsky, D., Kalkan, E. and Adalier, K. “Behavior of Reinforced Wall System during the 1999 Kocaeli (Izmit), Turkey Earthquake”, *Proc. of the 5th Int. Conf. on Case Histories in Geotechnical Engineering*: New York, NY, April 13-17, 2004.

A20. Kalkan, E., Adalier, K. and Pamuk, A. “Near Field Effects and Engineering Implications of Recent Earthquakes in Turkey”, *Proc. of the 5th International Conference on Case histories in Geotechnical Engineering*: New York, NY, April 13-17, 2004.

A21. Pamuk, A., Kalkan, E. and Ling, H.I. “Structural and Geotechnical Impacts of Surface Rupture on Highway Structures”, *Proc. of the 11th International Conference on Soil Dynamics & Earthquake Engineering:* University of California, Berkeley, CA, Jan. 7-9, 2004.

A22. Kalkan, E. and Gülkan, P. “Empirical Attenuation Equations for Vertical Ground Motion in Turkey”, *Earthquake Spectra*, **20**, (3), 853-882, Aug. 2004. **[14 citations]**

A23. Balkaya, C. and Kalkan E. “Three-Dimensional Effects on Openings of Laterally Loaded Pierced Shear Walls”, *ASCE Journal of Structural Engineering*: **130**, (10), 1506-1514, Oct. 2004. **[11 citations]**

A24. Kalkan, E. and Gülkan P. “Site-Dependent Spectra Derived from Ground Motion Records in Turkey”, *Earthquake Spectra*: **20**, (4), 1111-1138, November 2004. **[45 citations]**

A25. Kalkan, E. and Laefer, D.F. “Seismic Based Strengthening of Steel and RC Telecommunication Poles based on FEM analysis”, *Engineering Structures*: **26**, (14), 2101-2111, Dec. 2004.

A26. Balkaya, C. and Kalkan, E. “Seismic Vulnerability, Behavior and Design of Tunnel Form Buildings”, *Engineering Structures*: **26**, (14), pp. 2081-2099, Dec. 2004. **[12 citations]**

A27. Kunnath, S.K. and Kalkan, E. “Evaluation of Nonlinear Static Procedures for Different Seismic Source Characteristics”, *Proc. of the Earthquake Engineering in the Past and Future Fifty Years*, Harbin, China, August 19-21, 2004.

A28. Kunnath, S.K. and Kalkan, E. “Evaluation of Seismic Deformation Demands Using Nonlinear Procedures in Multistory Steel and Concrete Moment Frames”, *ISET, Journal of Earthquake Technology* (Invited paper for the special issue on Performance Based Design; Guest editor: N.J. Priestley): **41**, (1), 159-181, 2004. **[12 citations]**

A29. Gülkan, P. and Kalkan, E. “Attenuation Characteristics of Turkey Based on Recent Strong Ground Data”, *Bulletin of the Istanbul Technical University*: **54**, (2), 2004.

2005

A30. Kunnath, S.K. and Kalkan, E. “IDA Capacity Curves: The Need for Alternative Intensity Factors”, *Proc. of the American Society of Civil Engineers, Structures Congress*: New York, NY, April 20-24, 2005.

A31. Kalkan, E. and Gülkan P. “Discussion of the paper ‘An attenuation relationship based on Turkish strong motion data and iso-acceleration map of Turkey’ by Ulusay et al.” *Engineering Geology*: **79**, (3-4), 288-290, July 2005.

A32. Pamuk, A., Kalkan, E. and Ling, H.L. “Structural and Geotechnical Impacts of Surface Rupture on Highway Structures”, *Soil Dynamics and Earthquake Engineering*: **25**, (7-10), 581-589, Aug-Oct. 2005. **[17 citations]**

A33. Gülkan P. and Kalkan, E. “Discussion of the paper ‘An empirical attenuation relationship for Northwestern Turkey ground motion using a random effects approach’ by Ozbey et al.”, *Soil Dynamics and Earthquake Engineering*: **25**, (11), 889-891, Dec. 2005.

2006

A34. Kalkan, E. Predicting Seismic Demands of Building Structures, Ph. D. Dissertation, University of California, Davis, 2006.

A35. Kalkan, E. and Kunnath, S.K. “Adaptive Modal Combination Procedure for Predicting Seismic Response of Vertically Irregular Structural Systems”, *Proc. of the Eight National Earthquake Engineering Conference*: Paper No. 700, San Francisco, April 18 - 22, 2006.

A36. Kalkan E. and Kunnath S.K. “Adaptive Modal Combination Procedure for Nonlinear Static Analysis of Building Structures”, *ASCE Journal of Structural Engineering*, **132**, (11), 1721-1732, Nov. 2006. **[45 citations]**

A37. Laefer, D.F. Carr, H. Moorish, S. and Kalkan, E. “Opportunities and Impediments to the Use of Three-dimensional Laser Scanning for Integrated Monitoring of Adjacent Excavations”, *Proc. of the ASCE/GEO 2006 Congress*: Atlanta, Georgia, Feb. 26-March 1, 2006.

A38. Kalkan, E. and Kunnath, S.K. “Effects of Fling-Step and Forward Directivity on the Seismic Response of Buildings”, *Earthquake Spectra*: **22**, (2), 367-390, May 2006. **[21 citations]**

A39. Balkaya, C., Kalkan, E. and Yuksel, B. “FE Analysis and Practical Modeling of RC Multi-bin Circular Silos”, *ACI Structural Journal*: **103**, (3), 365-371, 2006.

2007

A40. Graizer, V. and Kalkan E. “Ground Motion Attenuation Model for Peak Horizontal Acceleration from Shallow Crustal Earthquakes”, *Earthquake Spectra*, **23**, (3), 585-613, 2007. [7 citations]

A41. Celebi, M. Kalkan, E. and Pezeshk, S. “Rotational Measurements in Structures – Why and How? - Engineers’ Perspective and Experience?”, First International Workshop on Rotational Seismology and Applications, USGS Open-File Report No: 2007-1144, 2007.

A42. Kalkan, E. and Graizer V. “Coupled Tilt and Translational Ground Motion Response Spectra”, *ASCE Journal of Structural Engineering*: **133**, (5), 609-619, 2007. **[15 citations]**

A43. Kalkan, E. and Graizer V. “Multi-Component Ground Motion Response Spectra for Coupled Horizontal, Vertical, Angular Accelerations and Tilt”, *ISET, Journal of Earthquake Technology (Invited paper for the special issue on “Response Spectra”; Guest editor: M. Trifunac)*: March 2007. **[7 citations]**

A44. Kalkan, E. and Yuksel, B. “Pros and Cons of RC Tunnel Form (Box-type) Buildings”, *The Structural Design of Tall and Special Buildings*: **16**, (2), June 2007. **[2 citations]**

A45. Kalkan, E. and Kunnath S.K. “Effective Cyclic Energy as a Measure of Seismic Demand”, *Journal of Earthquake Engineering*: **11**, (5), Sept. 2007. **[7 citations]**

A46. Kalkan, E. Kunnath, S.K. “Assessment of Current Nonlinear Static Procedures for Seismic Evaluation of Buildings”, *Engineering Structures*: **29**, 305-316, 2007. **[21 citations]**

A47. Yuksel, B. and Kalkan, E. “Behavior of Tunnel Form Buildings under Quasi-Static Cyclic Lateral Loading, *Structural Engineering and Mechanics*: **27**, (1), 2007.

2008

A48. Kalkan, E., Gulkan, P., Ozturk, N.Y., Celebi, M. “Seismic Hazard in the Istanbul Metropolitan Area: A Preliminary Re-examination”, *Journal of Earthquake Engineering*: **12**, (S2), 151-164, Jan. 2008.

A49. Kalkan, E. and Kunnath, S.K. “Relevance of Absolute and Relative Energy Content in Seismic Evaluation of Structures”, *Advances in Structural Engineering*: **11**, (1), 17-34, Feb. 2008. **[8 citations]**

A50. Yuksel, S.B. and Kalkan, E. “Failure Mechanism of Shear-Wall Dominant Multi-Story Buildings: Experimental and Analytical Study”, *Proc. of the Fourth International Conference on High Performance Structures and Materials*: Algarve, Portugal, 13-15 May, 2008.

A51. Goulet, C.A., Watson-Lamprey, J., Baker, J., Haselton, C.B., Stewart, J.P., Abrahamson, N., Bozorgnia, Y., Cornell A. Kalkan, E., Luco, N., Shome, N., Shantz, T., Tothong, P., Yang, T., Zareian, F. “Assessment of Ground Motion Selection and Modification methods for Non-linear Structural Analyses of Building Structures”, *Proc. of the ASCE Geotechnical Earthquake Engineering & Soil Dynamics Conference (GEESD IV)*: Sacramento, May, 2008.

A52. Graizer, V. and Kalkan, E. “Response of Pendulums to Complex Input Ground Motion”, *Soil Dynamics and Earthquake Engineering*: **28**, (8), 621–631, 2008. **[8 citations]**

---------- *Begin of USGS Employment, November, 2008* ----------

A53. Graizer, V. and Kalkan, E. “Graizer-Kalkan Ground Motion Prediction Model for PGV”, *Proc. of the 14th World Conference on Earthquake Engineering*: Beijing, China, 2008.

A54. Celebi, M. and Kalkan, E. “Status and needs for seismic instrumentation of structures along the Hayward fault”, *Proc. of the East Bay Conference*, 2008.

A55. Kalkan, E., Wills, C.J., and Branum, D.M. “Seismic Hazard Mapping of California Incorporating Spatial Variability of Site Conditions”, *Proc. of the East Bay Conference*, 2008.

2009

A56. Graizer, V. and Kalkan, E. “Prediction of Response Spectral Acceleration Ordinates based on PGA Attenuation”, *Earthquake Spectra*: **25**, (1), 36 – 69, Feb. 2009.

A57. Haselton, C., Baker, J.W., Bozorgnia, Y., Goulet, C.A., Kalkan, E. Luco, N. Shantz, T., Shome, N., Stewart, J.P., Tothong, P., Watson-Lamprey, J. and Zareian, F., “Evaluation of Ground Motion Selection and Modification Methods: Predicting Median Interstory Drift Response of Buildings”, PEER Report No: 2009/01, Pacific Earthquake Engineering Research Center College of Engineering University of

California, Berkeley, p. 219, June 2009.

A58. Kalkan E., Gulkan, P., Yilmaz, N., Celebi, M. “Re-Examination of Probabilistic Seismic Hazard in the Marmara Sea Region”, *Bulletin of Seismological Society of America*: **99**, (4), 2127–2146, Aug. 2009.

A59. Kalkan, E. and Celebi, M. “Assessment of ASCE 7-05 Ground Motion Scaling Method Using Computer Model of Instrumented High-Rise Building”, *Proc. of the ATC/SEI Conference*: San Francisco, 2009.

A60. Kalkan, E. and Chopra, A.K. “Modal Pushover-based Ground Motion Scaling Procedure for Nonlinear Response History Analysis of Structures”, *Proc. of the Structural Engineering Association of California, Annual Convention*: San Diego, 2009.

2010

A61. Graizer, V., Kalkan, E. and Lin, K.W. “Extending and Testing Graizer-Kalkan Ground Motion Attenuation Model based on Atlas Database of Shallow Crustal Events”, *Proc. of the National Earthquake Engineering Conference*: Toronto, Canada, July 2010.

A62. Kalkan, E. and Gulkan, P. “Earthquake Hazard in Istanbul and Its Surroundings”, *Science and Technics*: (in-Turkish) **513**, Aug., 2010.

A63. Çelebi, M. P., Bazzurro, L., Chiaraluce, P., Clemente, L., Decanini, A., DeSortis, W., Ellsworth, A., Gorini, Kalkan, E., Marcucci, G., Milana, F., Mollaioli, M., Olivieri, D., Rinaldis, A., Rovelli, F., Sabetta, and C. Stephens. ”Recorded Motions of the Mw6.3 April 6, 2009 L’Aquila (Italy) Earthquake and Implications for Building Structural Damage”, *Earthquake Spectra*: **26**, (3), pp. 651-684, Aug., 2010.

A64. Kalkan, E., Wills, C.J., and Branum, D.M. “Seismic Hazard Mapping of California Considering Site Effects”, *Earthquake Spectra*: **26**, (3), pp. 1039-1055, Nov. 2010.

A65. Kalkan, E. and Chopra, A.K. Practical Guidelines to Select and Scale Earthquake Records for Nonlinear Response History Analysis of Structures, USGS Open-File Report No: 2010-1068, 126 p. 2010.

2011

A66. Graizer, V. and Kalkan, E. “Modular Filter-Based Approach to Ground Motion Attenuation Modeling", *Seismological Research Letters*: **82**, (1), 21-31, Jan-Feb. 2011.

A67. Akkar, S., Aldemir, A., Askan, A., Bakır, S., Canbay, E., Demirel, O., Erberik, A., Gülerce, Z., Gülkan, P., Kalkan, E., Prakash, S., Sandıkkaya, A., Sevilgen, V., Ugurhan, B., Yenier, E., “8 March 2010 Elazıg-Kovancılar (Turkey) Earthquake: Observations on Ground Motions and Building Damage”, *Seismological Research Letters*: **82**, (1), 42-58, Jan-Feb, 2011.

A68. Kalkan, E. and Kwong, N.S., Documentation for Assessment of Modal Pushover-based Scaling Procedure for Nonlinear Response History Analysis of “Ordinary Standard” Bridges, U.S. Geological Survey Open-File Report No: 2010-1328, p. 56, 2011.

A69. Kalkan, E. and Chopra, A.K., “Modal-Pushover-based Ground Motion Scaling Procedure”, *ASCE Journal of Structural Engineering*: **138** (3), 289-310, March, 2011.

A70. Reyes, J.C. and Kalkan, E., Required Number of Ground Motion Records for ASCE/SEI 7 Ground Motion Scaling Procedure: U.S. Geological Survey Open-File Report No: 2011-1083, 34 p. 2011.

A71. Kalkan, E. and Chopra, A.K. “Evaluation of Modal Pushover-based Scaling of one Component of Ground Motion: Tall Buildings”, *Earthquake Spectra*, 2011 (in-press).

A72. Reyes, J.C. and Kalkan, E. “How Many Records Should be Used in ASCE/SEI-7 Ground Motion Scaling Procedure", *Earthquake Spectra*, 2011 (in-press).

A73. O’Donnell, A.P. Beltsar, O.A., Kurama, Y.C., Kalkan, E. and Taflanidis, A.A., “Evaluation of Ground Motion Scaling Methods for Analysis of Structural Systems”, *Proc. of the American Society of Civil Engineers, Structures Congress*: Las Vegas, NV, April 13-16, 2011.

A74. Hatayama, K. and Kalkan, E. “Long-Period (3 to 10 s) Ground Motions in and around the Los Angeles Basin during the Mw7.2 El-Mayor Cucapah Earthquake of April 4, 2010”, *Proc. of the 4th IASPEI / IAEE International Symposium*, August 23–26, 2011, University of California Santa Barbara.

A75. Segou, M. and Kalkan, E. “Ground Motion Attenuation during M7.1 Darfield and M6.3 Christchurch (New Zealand) Earthquakes and Performance of Global Predictive Models", *Seismological Research Letters*, Nov-Dec issue, 2011 (in-press).

A76. O’Donnell, A.P. Kurama, Y.C., Kalkan, E. and Taflanidis, A.A., Beltsar, O.A., “Experimental evaluation of ground motion scaling methods for structures with limited nonlinearity”, *Earthquake Engineering and Structural Dynamics*, 2011 (submitted for publication).

A77. Kalkan, E. and Graizer, V. “Global v's Central and Eastern U.S. Attenuation Models in Predicting Ground Motions of the M5.8 Mineral, Virginia Earthquake”, *Seismological Research Letters*, 2011 (submitted for publication).

A78. Graizer, V. Kalkan, E. and Lin, K. “Global Ground Motion Prediction Model for Shallow Crustal Regions”, *Earthquake Spectra*, 2011. (submitted for publication).

(19) SELECTED PUBLICATIONS

1) Kalkan E. and Chopra, A.K. “Modal-Pushover-based Ground Motion Scaling Procedure”, *ASCE Journal of Structural Engineering*: Mar. 2011.

BACKGROUND – Over the past decade, considerable progress have been made in developing tools to predict nonlinear response of structures to ground motions, an important consideration in the design and assessment of earthquake-resistant structures. With increase in computational power, non-linear response history analysis (RHA) is becoming a common tool in practice. This rigorous method of analysis requires a suite of records as direct input. These records should be selected and scaled appropriately to make them compatible with the site-specific hazard level considered. Today, practitioners are faced with emergence of numerous different intensity-based and spectral-matching type methods for scaling of records without having sound documentation for their details or their suitability under different hazard conditions or structural systems. Considering the large variations in sources influencing the ground motions’ intensity and frequency content (e.g., magnitude, distance, directivity, geological and topographical conditions etc.), selection of records with confidence has also remained a major challenge for engineers. Owing these facts, there is an urgent need for practical guidelines that can bridge the gap between seismologists and structural engineers so that both sets of knowledge and understanding can join to describe how a certain suite of records would affect the response results, and how they should be selected and scaled to achieve robust prediction of earthquake response of structures.

RESULTS AND SIGNIFICANCE – This manuscript provides a new practical methodology to select and scale earthquake records for nonlinear response history analysis of structures, so called “modal-pushover based ground motion scaling” (MPS) methodology. In MPS, the ground motions are scaled to match (to a specified tolerance) a target value of the inelastic deformation of the first-”mode” inelastic single-degree-of-freedom (SDF) system whose properties are determined by first-”mode” pushover analysis. Appropriate for first-”mode” dominated structures (e.g., low and mid-rise buildings), this approach is extended for structures with significant contributions of higher modes (e.g., tall buildings) by considering elastic deformation of second-“mode” SDF system in selecting a subset of the scaled ground motions. This manuscript establishes the accuracy and efficiency of the developed MPS procedure and demonstrates its superiority over the regulatory ASCE/SEI 7-05 scaling procedure. This paper, part of the USGS Open File report 2010-1068, has been nominated for the American Society of Civil Engineers 2012 Norman Medal – this nomination is still under evaluation.

IMPACT – This Earthquake Engineering Research Institute, FEMA and NEHRP funded study has been influencing the design practice since 2010 following the publication of two USGS Open File Reports providing design guidelines for engineers and engineering-seismologists to select and scale ground motions for use in nonlinear response history analysis of buildings and bridges. The developed methodology has been used in design practice (including the Nuclear Industry) by structural engineering firms in their design projects, where ground motion time series are required for design verification. The dedicated web pages of this study (http://nsmp.wr.usgs.gov/ekalkan/MPS/index.html & http://nsmp.wr.usgs.gov/ekalkan/MPS_Bridge/index.html) have been visited more than 500 times since May 2010 by visitors from more than 30 countries. An associated NEHRP proposal is currently underway in order to include the developed methodology in the next generation of the U.S. International Building Code.

2) **Kalkan, E., Wills, C.J., and Branum, D.M. “Seismic Hazard Mapping of California Considering Site Effects”, *Earthquake Spectra*: Vol. 26, no. 3, pp. 1039-1055, Nov. 2010. [This paper became the cover story of the journal of Earthquake Spectra]**

BACKGROUND – The U.S. Geological Survey has released a 2008 version of the National Seismic Hazard Maps. These maps plot the peak ground acceleration (PGA) and spectral acceleration (SA) at 0.2 and 1.0 sec with 2% and 10% probability of exceedance (PE) in 50 years. These acceleration levels were computed for uniform “firm rock” site conditions only (VS30 = 760 m/sec), and therefore the potential spatial variability of ground motion associated with different site conditions is not considered.

RESULTS AND SIGNIFICANCE – In this study, we have combined the National Seismic Hazard model with the California geologic map showing 17 generalized geologic units that can be defined by their VS30. We regrouped these units into 7 VS30 values and calculated a probabilistic seismic hazard map for the entire state for each VS30 value. By merging seismic hazard maps based on the 7 different VS30 values, a suite of seismic hazard maps was computed for 0.2 and 1.0 sec spectral ordinates at 2% PE in 50 years. The improved hazards maps explicitly incorporate the site effects and their spatial variability on ground motion estimates.

IMPACT – The SA at 1.0 sec map of seismic shaking potential for California has been now published as California Geological Survey Map Sheet 48; this map allows non-scientists to understand the overall distribution of seismic shaking hazards, including the effects of amplification by near-surface soils. The map has been distributed to planners and emergency preparedness officials by California Geological Survey to evaluate the relative hazards across the state so that hazard mitigation efforts can be focused on the most hazardous areas. A dedicated web page

(http://nsmp.wr.usgs.gov/ekalkan/California/index.html) of this project provides an interactive environment for the visitors to explore the seismic hazard and geology of California using the Google-Earth API; visitors from 17 countries have visited this web page 202 times since May 2010 after its release. The manuscript summarizing this study became the cover story of the journal of Earthquake Spectra (Vol. 26, no. 3, Nov. 2010). The next generation of national hazard maps is expected to incorporate the site effects following the similar procedure described in our paper.

3) **Kalkan E. and Kunnath S.K. "Adaptive Modal Combination Procedure for Nonlinear Static Analysis of Building Structures", *ASCE Journal of Structural Engineering*, Vol. 132, no. 11, pp. 1721-1732, Nov. 2006. [This award-winner paper has been cited 45 times]**

BACKGROUND – The advancement of performance-based procedures in seismic design relies greatly on advancements in analytical methods to predict inelastic dynamic response of building structures. A commonly utilized analytical method in practice for response prediction is nonlinear static analysis (that is, pushover analysis).

RESULTS AND SIGNIFICANCE – In this manuscript, a new pushover technique utilizing adaptive multimodal displacement patterns is developed with the objective of retaining the advantages of both adaptive and modal pushover procedures. The proposed adaptive modal combination procedure eliminates the need to pre-estimate the target displacement and utilizes an energy-based scheme to achieve stable estimates of the seismic demand in conjunction with constant-ductility inelastic spectra. It is shown to provide reasonable estimates of seismic demand in typical moment frame structures for both far-fault and near-fault records, and consequently provides a reliable tool for performance assessment of building structures.

IMPACT – This manuscript describing this study has been selected for the **2008 American Society of Civil Engineers Raymond C. Reese Research Prize**. The prize was awarded for describing a notable achievement in research related to structural engineering and recommending how the results of that research can be applied to design. This paper has been cited by 44 times so far (according to the Google-Scholar), numerous researchers worldwide have requested for the adaptive pushover code that I developed in open source finite element platform to be used in their research studies.